



Equitable Spectrum Allocation Using Occupied Spectral Units

By Thomas Kidd - July-September 2018

Equitable spectrum allocation among federal and non-federal users has been a point of continual debate across the course of American spectrum history. The debate was fueled by the perception that federal agencies have exclusive access to an inordinate quantity of spectrum. Typically, this results in spectrum reallocation, auction, or restrictions in shared spectrum.

In this article, we discuss different methods of computing spectrum equity with comparisons of spectrum allocation using total number of hertz (Hz) and number of frequency bands. We will also introduce an alternative measure of spectrum equity based on the amount of spectrum allocated relative to its location in the spectrum. We will call this measure the "Occupied Spectral Unit." The intent of this article is to offer an alternative to counting total hertz or the number of frequency bands in determining equitable spectrum allocation.

Counting Hertz. A total of 274,999,991,700 Hz are available for use within the United States. Federal government users, such as the Departments of Interior, Justice and Defense, are allocated 1.9 percent, or 4,795,537,500 Hz, for their exclusive use. Non-federal users such as local police, fire and industry (e.g., cellular telephone) are allocated 5.3 percent, or 12,929,804,500 Hz, for their exclusive use. Federal and non-federal users share 12.4 percent, or 30,426,720,000 Hz, with each group having different rights to the same spectrum. The remaining 80.4 percent, or 197,997,929,670 Hz, is unified spectrum, in which both federal and non-federal users have the same rights to the same spectrum. (See Figure 1.)

Counting Frequency Bands. The electromagnetic spectrum is also allocated in 559 frequency bands, beginning from 8.3kHz and extending up to 275GHz. Forty-nine bands, 8.9 percent, are set aside for exclusive use by federal government users and 134 bands, 24 percent, are exclusively for non-federal users.

Federal and non-federal users share 155 bands, 27.7 percent, with each having different rights in the same band. The remaining 221 frequency bands, 39.5 percent, are unified spectrum, with the same rights for both federal and non-federal users. (See Figure 2.)

Neither of these measurements take into account the size and location of frequency bands in the electromagnetic spectrum, which can determine value/capability. Frequency bands in the lower end of the spectrum are much smaller, containing fewer hertz, than bands in the upper ranges of the spectrum. The value per hertz changes in different parts of the spectrum. In part, this is because frequency bands get larger at a logarithmic rate. The following analogy illustrates why a simple count of hertz or frequency bands is not optimum.

Imagine two people, each with 100 pounds of metal. By some measures, both have an equal amount. However, suppose one person has 10 pounds of gold, 10 pounds of silver, and 80 pounds of copper. The other person has 20 pounds of gold, 20 pounds of silver, and 60 pounds of copper. From a metal value measurement, the two are no longer equal. Resource equity depends on how the resource is valued.

Frequency bands are valued by their utility and location in the spectrum. Different portions of the spectrum have different utility. And the amount of spectrum required for a given level of utility varies depending on the location of the frequency band in the spectrum. Systems operating at lower frequencies typically require less spectrum to function than systems operating at higher frequencies. One channel in a lower frequency device may be a few thousand hertz while a high frequency device may require a few billion hertz. To discuss spectrum allocation equitably, we need a method of calculating relative spectrum utility regardless of the frequency band location in the electromagnetic spectrum; we must use a relative scale.

Occupied Spectral Units. As addressed above, determining spectrum parity by counting either total hertz or frequency bands may not provide an accurate representation. An alternative measure should be based on the relative amount of spectrum allocated. We will call this measure "Occupied Spectral Units." To determine Occupied Spectral Units for any of the 559 frequency bands, we divided the total number of hertz in the band by the center frequency of the band. For example, the

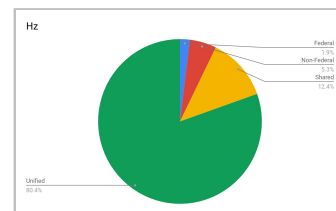


Figure 1.

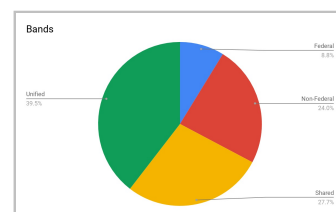


Figure 2.

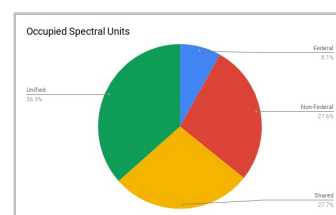


Figure 3.

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frequency band 1675-1700 MHz would be calculated by dividing the 25 MHz band size by 1687.5 MHz center frequency. Totalling the Occupied Spectral Units for each of the 49 federal exclusive, 134 non-federal exclusive, 155 shared, and 221 unified frequency band we see that the federal government is allocated 8.1 percent of the total occupied spectrum, non-federal is allocated 27.6 percent, 27.7 percent is shared, and 36.5 percent is unified. (See Figure 3.)

Spectrum is critical to both our national security and our nation's economy. It is vital that discussions of spectrum equity be in the right context. Counting hertz and frequency bands are not the most optimum calculations; a measure like Occupied Spectral Units is more accurate for this discussion. This measure is easily calculated in any frequency band, and then reapplied to calculate similar levels of occupancy in other frequency bands.

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